Research Brief

Wisconsin Highway Research Program
Project 0092-17-08
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Monitoring Lateral Earth Pressures and Movements of Cut Retaining Walls

Research Objectives

- Investigate the short-term and long-term performance of cut retaining walls
- Develop guidance to accurately predict horizontal and vertical earth movements behind cut retaining walls
- Obtain data for calibrating design methodologies for cut retaining walls

Research Benefits

- Identified methods for more accurately predicting earth movement and estimating strength and service limit states of cut retaining walls
- Recommended modifications to analysis and design methods that will improve cut retaining wall performance

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Background

Retaining walls are barriers built to protect roads, rights-of-way, utilities and structures from the lateral movement of soil. Cut retaining walls, such as soldier pile/lagging walls, sheet pile walls and tangent/secant pile walls, are constructed top down. Accurate estimates of complex lateral and vertical soil-structure interactions that determine earth pressure against these walls are necessary for evaluating strength and service limit states.

The objective of this project was to develop guidance to accurately predict horizontal and vertical movements; obtain data for calibration of specific design methodologies; and provide recommendations for limit states that can be used to control wall performance.

Methodology

Two cut retaining walls (one cantilevered wall and one anchored wall) on an active construction project were instrumented and remotely monitored over a 15-month period.

A Shaped Array Accelerometer secured at ground level.

Automated readings from strain gages, inclinometers using Shaped Array Accelerometers (SAA), survey points, vibrating wire piezometers (VWPZ) and load cells were collected to obtain measurements of each wall's displacement, strains in each wall's structural elements and pore pressures in the retained soil. The research team compared predicted design performance as computed by two programs (SPW-911 and PY-Wall) to the actual measured performance of each wall.

Results

Piezometers recorded positive pore pressures behind the walls after construction, indicating that the as-built walls may have been preventing lateral seepage. SAA readings showed seasonal outward movement that rebounded after the winter season, indicating that the movement was likely related to freezing and thawing of the

"WisDOT learned a lot about the behavior and performance of cut retaining walls through this research. This will allow us the ability to calibrate our design procedures, which will lead to more cost-effective structures."
– Andrew Zimmer, WisDOT

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ground during the winter months. Wall movements measured with the SAAs were repeatable and consistent over time. Moments deduced from the wall movements measured with the SAAs were consistent with those deduced from strain gages. The SAA data were superior because they were able to capture the maximum moments. Back calculations of earth pressures from measured deformations using SAA readings were erratic and sensitive to small changes in the readings. Back-calculated earth pressures require careful consideration of reaction forces provided by slabs and anchors.

Recommendations for implementation

The research team provided the following recommendations for WisDOT to consider in its future design practices:

- Include all applicable load cases in design to ensure that worst case loading, or a combination of loading, is addressed.
- Develop standard details for protection against pore water pressure buildup and ground freezing behind the wall.
- Consider undrained and drained cases for each wall design to cover various possibilities that can develop in the field during construction and post construction.
- When using the PY-WALL method, obtain soil parameters for actual site conditions using appropriate site-specific testing rather than using the p-y curves internally generated by the software.
- Have specifications require performance testing of a representative number of anchors to reduce uncertainty in the actual anchor lock-off loads.
- Require contractors to conduct higher-quality documentation of their sequence of work to aid in interpreting retaining wall performance.
- For unusual cases, and cases where poor wall performance could create significant risks and costs, instrument and monitor representative wall sections to better understand and manage future performance.
- For cut walls where the zone of influence of construction might include existing utilities and/or buildings sensitive to ground movement, require alternative software to SPW911 and PY-Wall (such as Finite Element Analysis) to predict ground settlements, as neither program calculates ground settlement behind the wall.

This brief summarizes Project 0092-17-08,
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